DEPARTMENT OF MECHANICAL ENGINEERING

M.TECH. – MACHINE DESIGN

SCHEME & SYLLABUS

A.Y. 2016-17 ONWARDS
BMS COLLEGE OF ENGINEERING, BENGALURU
Autonomous College under VTU

VISION

Promoting Prosperity of mankind by augmenting human resource capital through Quality Technical Education & Training

MISSION

Accomplish excellence in the field of Technical Education through Education, Research and Service needs of society

DEPARTMENT OF MECHANICAL ENGINEERING

DEPARTMENT VISION

To become a center of excellence in educating students to become successful Mechanical Engineers

DEPARTMENT MISSION

• To empower the students with the fundamentals for a successful career in the field of Mechanical engineering.
• To continue their education through post-graduation, Research & Development.
• To provide service to the society.

Scheme and Syllabus for M.Tech. (Machine Design)
With effect from A. Y. 2016 – 17
# M.Tech. (Machine Design) - Programme Educational Objectives

<table>
<thead>
<tr>
<th>PEO</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEO1</td>
<td>Graduates will have knowledge in the discipline of Machine Design with hands on skill in using modern engineering tools to address real world engineering problems and be socially responsible.</td>
</tr>
<tr>
<td>PEO2</td>
<td>Graduates shall be successful in their career as analysts and designers of structural components of conventional and advanced materials, participating in a team or individually in an industry, research or academia.</td>
</tr>
<tr>
<td>PEO3</td>
<td>Graduates shall be proficient in their communication, presentation and will be prepared to engage in the process of life-long learning through professional development and research.</td>
</tr>
</tbody>
</table>

## Programme Outcomes

<table>
<thead>
<tr>
<th>PO No.</th>
<th>Programme Outcomes (PO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO1</td>
<td>Acquire in-depth knowledge of specific discipline or professional area, including wider and global perspective, with an ability to discriminate, evaluate, analyse and synthesise existing and new knowledge, and integration of the same for enhancement of knowledge.</td>
</tr>
<tr>
<td>PO2</td>
<td>Analyse complex engineering problems critically, apply independent judgment for synthesising information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context</td>
</tr>
<tr>
<td>PO3</td>
<td>Think laterally and originally, conceptualise and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.</td>
</tr>
<tr>
<td>PO4</td>
<td>Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyse and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in one or more domains of engineering.</td>
</tr>
<tr>
<td>PO5</td>
<td>Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities with an understanding of the limitations.</td>
</tr>
<tr>
<td>PO6</td>
<td>Possess knowledge and understanding of group dynamics, recognise opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.</td>
</tr>
<tr>
<td>PO7</td>
<td>Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economic and financial factors.</td>
</tr>
<tr>
<td>PO8</td>
<td>Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.</td>
</tr>
<tr>
<td>PO9</td>
<td>Recognise the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.</td>
</tr>
<tr>
<td>PO10</td>
<td>Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.</td>
</tr>
<tr>
<td>PO11</td>
<td>Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.</td>
</tr>
</tbody>
</table>
## Scheme of Instruction for First Semester M. Tech. in Machine Design 2016-2017

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Subject Code</th>
<th>Name of the Subject</th>
<th>Credits</th>
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<th>Credits</th>
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<tbody>
<tr>
<td>1</td>
<td>16MEMDPCAS</td>
<td>Advanced Mechanics of Solids</td>
<td>L 4</td>
<td>T 0</td>
<td>P 0</td>
<td>S 0</td>
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<tr>
<td>2</td>
<td>16MEMDPCDM</td>
<td>Dynamics and Mechanism Design</td>
<td>L 3</td>
<td>T 0</td>
<td>P 1</td>
<td>S 0</td>
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<tr>
<td>3</td>
<td>16MEMDPCAD</td>
<td>Advanced Machine Design</td>
<td>L 4</td>
<td>T 0</td>
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<tr>
<td>4</td>
<td>16MEMDPCFE</td>
<td>Finite Element Method</td>
<td>L 3</td>
<td>T 0</td>
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<td>16MEMDPEXX</td>
<td>Elective–I</td>
<td>L 3</td>
<td>T 0</td>
<td>P 0</td>
<td>S 0</td>
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<tr>
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<td>Elective–II</td>
<td>L 3</td>
<td>T 0</td>
<td>P 0</td>
<td>S 0</td>
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<tr>
<td>7</td>
<td>16MEMDPCD1</td>
<td>Design Laboratory - I</td>
<td>L 0</td>
<td>T 0</td>
<td>P 1</td>
<td>S 0</td>
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<tr>
<td>8</td>
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<td>Research Methodology</td>
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<td><strong>P 2</strong></td>
<td><strong>S 1</strong></td>
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**Note:** Electives to be chosen one from each group.
Elective will be offered for a minimum strength of six candidates (out of 18) / eight candidates (out of 24)

### Elective I

<table>
<thead>
<tr>
<th>Sub: Code</th>
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<tr>
<td>16MEMDPECM</td>
<td>Composite Materials Technology</td>
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<tr>
<td>16MEMDPEMD</td>
<td>Mechatronics Systems Design</td>
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<tr>
<td>16MEMDPERD</td>
<td>Robust Design</td>
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### Elective II

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<th>Sub: Code</th>
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<tr>
<td>16MEMDPEC</td>
<td>Computational Methods in Engineering Analysis</td>
</tr>
<tr>
<td>16MEMDPESE</td>
<td>Statistical Modeling and Experimental Design</td>
</tr>
<tr>
<td>16MEMDPEOT</td>
<td>Optimization Techniques</td>
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## Scheme of Instruction for Second Semester M. Tech. in Machine Design 2016-2017

<table>
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<td>Vibrations &amp; Acoustics</td>
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<td>16MEMDPCTR</td>
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<td>4</td>
<td>16MEMDPEXX</td>
<td>Elective-III</td>
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<td>5</td>
<td>16MEMDPEXX</td>
<td>Elective-IV</td>
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*Note: Electives to be chosen one from each group. Elective will be offered for a minimum strength of six candidates (out of 18) / eight candidates (out of 24)*

### Elective III

<table>
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<tr>
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<tbody>
<tr>
<td>16MEMDPETP</td>
<td>Theory of Plasticity</td>
</tr>
<tr>
<td>16MEMDPERT</td>
<td>Rotor Dynamics</td>
</tr>
<tr>
<td>16MEMDPETS</td>
<td>Theory of Plates and Shells</td>
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### Elective IV

<table>
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<th>Subject</th>
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<tbody>
<tr>
<td>16MEMDPEEM</td>
<td>Experimental Mechanics</td>
</tr>
<tr>
<td>16MEMDPEDF</td>
<td>Design for manufacture</td>
</tr>
<tr>
<td>16MEMDPERB</td>
<td>Robotics</td>
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### Elective V (Institutional)

<table>
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<th>Sub: Code</th>
<th>Subject</th>
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<tbody>
<tr>
<td>16MEMDIECA</td>
<td>Computer Applications in Design</td>
</tr>
<tr>
<td>16MEMDIECG</td>
<td>Computer Graphics</td>
</tr>
<tr>
<td>16MEMDIESS</td>
<td>Smart Materials and Structures</td>
</tr>
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</table>
### Scheme of Instruction for Third Semester M. Tech. in Machine Design 2016-2017

<table>
<thead>
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<th>Credits</th>
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</thead>
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<td></td>
<td></td>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>1</td>
<td>16MEMDPCIN</td>
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<td><strong>Total</strong></td>
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**NOTE: III Semester:**

- **Internship:** The student shall undergo internship for 16 weeks.
  
  **Preliminary Report** submission and Evaluation after 8th week of Internship to be carried out by the Internal Guide of the college and a senior faculty for 100 marks.
  
  **Final Report** submission and Evaluation after 16th week of Internship to be carried out by the Internal Guide of the college and a senior faculty of Dept. Report Evaluation to be completed within two weeks of submission for 100 marks.
  
  **Viva-Voce on Internship** - To be conducted by the Internship Guide (from the college) and the External Guide / Examiner within 2 weeks of Submission with a senior faculty / HoD as chairman for 100 marks.

- **Project Phase: I**
  
  **Problem formulation** and submission of **synopsis** within 8 weeks from the commencement of 3rd semester, which shall be evaluated for 50 marks by the committee constituted for the purpose by the Head of the Department comprising the guide, senior faculty of the department with HoD as Chairman.
  
  **Literature survey and progress** done after 16 weeks shall be evaluated by guide and external examiner with senior faculty / HoD as chairman for 50 marks.
IV Semester:

- **Project Phase-II** - Internal Evaluation of progress in Project work shall be evaluated after 8 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department comprising the guide and senior faculty of the department with HoD as Chairman.

- **Project Phase-III** - Internal Evaluation of Project Demonstration, which shall be evaluated after 15 weeks for 100 marks by the committee constituted for the purpose by the Head of the Department.

- **Final Evaluation of Project Work and Viva-voce.**
  - Final evaluation of project to be carried out after 16 weeks from the date of commencement of 4th semester.
  - The Internal Examiner (the project guide with a teaching experience of at least three years) and External Examiner with HoD as chairman will complete the final evaluation of Project.

- Internal and External Examiners shall carry out the evaluation for 100 Marks each and the average of these marks shall be the final marks of the Project Evaluation.

- **Viva – Voce** : The Viva-Voce shall be conducted jointly by Internal Examiner and External Examiner with HoD as chairman for 100 Marks.
Course Content:

UNIT - I
Introduction to Stress: Definition and Notation for forces and stresses. Components of stresses, equations of Equilibrium, Specification of stress at a point. Principal stresses and shear stresses and Mohr's diagram in three dimensions. Boundary conditions. Stress transformation, Stress components on an arbitrary plane, Stress invariants, Octahedral stresses, Decomposition of state of stress. 8 Hours

UNIT - II
Introduction to Strain: Deformation, Strain Displacement relations, Strain components, The state of strain at a point, Principal strain, Strain transformation, Compatibility equations, Cubical dilatation. Stress -Strain Relations and the General Equations of Elasticity: Generalized Hooke's; law in terms of engineering constants. Formulation of elasticity Problems. Existence and uniqueness of solution, Saint - Venant's principle, Principle of super position and reciprocal theorem. 14 Hours

UNIT – III
Energy Methods: Work done by forces and elastic strain energy stored, Begg’s Deformeter, First theorem of Castigliano, Theorem of virtual work, Kirchhoff’s theorem. 6 Hours

UNIT – IV
Two Dimensional Problems in Cartesian Co-Ordinates: Airy's stress function, investigation for simple beam problems. Bending of a narrow cantilever beam under end load, simply supported beam with uniform load, Use of Fourier series to solve two dimensional problems. 8 Hours

UNIT - V
Two Dimensional Problems in Polar Co-Ordinates: General equations, stress distribution symmetrical about an axis, Thick cylinder, shrink fit, Strain components in polar co-ordinates, Rotating disk and cylinder, Thermal stresses in thin discs, Stress concentration around a circular hole in an infinite plate. Thermo-elastic stress –strain relations.

Torsion of Prismatic Bars: Torsion of Circular and elliptical cross section bars, Membrane analogy, Torsion of thin walled closed tubes. 16 Hours

Text Books:

References Books:
1. T. G. Sitharam, Applied Elasticity - Interline publishing.
3. Sadhu Singh , Theory of Elasticity, Khanna publisher

Course Outcomes:
Upon completion of this course, student will be able to:

| CO 1 | Apply basic concepts in continuum mechanics of solids viz. Stress and strain tensors, equilibrium, compatibility and constitutive equations and methods of solution to elasticity problems |
| CO 2 | Evaluate stresses and displacements in simple solids such as pressurized cylinders, shrink fitted cylinders, rotating disc and shaft, plate with hole and non-circular shafts and thin tubes under torsion. |
| CO 3 | Use MATLAB or equivalent software to evaluate and plot particular solutions. |
| CO 4 | Apply principles of continuum mechanics to design a structure or component to achieve desired performance under realistic constraints. |

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, III, IV and Two questions each from units II & V.
Course Content:

UNIT - I
Geometry of Motion: Introduction, analysis and synthesis, Mechanism terminology, planar, Spherical and spatial mechanisms, mobility, Grashoff's law, Equivalent mechanisms, Unique mechanisms, Inversions of mechanism. 03 Hours

UNIT - II
Synthesis of Linkages: Type, number, and dimensional synthesis, Function generation, Path generation and Body guidance, Precision positions, Structural error, Chebychev spacing, Two position synthesis of slider crank mechanisms, Crank-rocker mechanisms with optimum transmission angle. Motion Generation: Poles and relative poles, Location of poles and relative poles, poleode, Curvature, Inflection circle. 07 Hours

UNIT - III
Graphical Methods of Dimensional Synthesis: Two position synthesis of crank and rocker mechanisms, Three position synthesis, Four position synthesis (point precision reduction) Overlay method, Coupler curve synthesis, Cognate linkages. 08 Hours
Analytical Methods of Dimensional Synthesis: Freudenstein's equation for four bar mechanism and slider crank mechanism, Examples, Bloch's method of synthesis, Analytical synthesis using complex algebra. 06 Hours

UNIT - IV

UNIT – V
System Dynamics: Gyroscopic action in machines, Euler's equation of motion, Phase Plane representation, Phase plane Analysis, Response of Linear Systems to transient disturbances. 05 Hours.

List of Practical's:
1. Kinematic analysis of four bar mechanism and slider bar mechanism using ADAMS Software.
2. Kinematic analysis of complex mechanisms using ADAMS Software.
3. Develop a code in MATLAB to for kinematic analysis of four bar mechanism and slider bar mechanism.
4. Write a MATLAB code to synthesize a four bar mechanism using Freudenstein’s method for function generation.
5. Write a MATLAB code to generate phase plane plot.
Text Books:

References Books:

Course Outcomes:
Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Carry out mobility analysis of mechanism and perform velocity and acceleration of complex planer mechanism.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Synthesize mechanisms for function generation and path generation.</td>
</tr>
<tr>
<td>CO3</td>
<td>Analyze the Dynamics of Mechanical systems using D’Alemberts, Lagrange’s, and Hamiltons Principles.</td>
</tr>
<tr>
<td>CO4</td>
<td>Demonstrate the skills to use software to analyze mechanisms</td>
</tr>
</tbody>
</table>

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, II, V and Two questions each from units III & IV.
Course Content:

UNIT - I
Introduction: Role of failure prevention analysis in mechanical design, Modes of mechanical failure, Review of failure theories for ductile and brittle materials including Mohr’s theory and modified Mohr’s theory, Numerical examples.
Fatigue of Materials: Introductory concepts, High cycle and low cycle fatigue, Fatigue design models, Fatigue design methods, Fatigue design criteria, Fatigue testing, Test methods and standard test specimens, Fatigue fracture surfaces and macroscopic features, Fatigue mechanisms and microscopic features.

UNIT - II
Strain-Life (ε-N) approach: Monotonic stress-strain behavior, Strain controlled test methods, Cyclic stress-strain behavior, Strain based approach to life estimation, Determination of strain life fatigue properties, Mean stress effects, Effect of surface finish, Life estimation by \( \varepsilon-N \) approach.

UNIT - III
LEFM Approach: LEFM concepts, Crack tip plastic zone, Fracture toughness, Fatigue crack growth, Mean stress effects. Notches and their effects: Concentrations and gradients in stress and strain, S-N approach for notched membranes, mean stress effects and Haigh diagrams, Notch strain analysis and the strain – life approach. Neuber’s rule.

UNIT - IV
Fatigue from Variable Amplitude Loading: Spectrum loads and cumulative damage, Damage quantification and the concepts of damage fraction and accumulation, Cumulative damage theories, Load interaction and sequence effects, Cycle counting methods, Life estimation using stress life approach.

UNIT - V
Surface Failure: Introduction, Surface geometry, Mating surface, Friction, Adhesive wear, Abrasive wear, Corrosion wear, Surface fatigue spherical contact, Cylindrical contact, General contact, Dynamic contact stresses, Surface fatigue strength.

Text Books:
Reference Books:

Course Outcomes:
Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Predict failure of engineering components using appropriate failure theories.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Identify and explain the types of fractures of engineered materials and their characteristic features;</td>
</tr>
<tr>
<td>CO3</td>
<td>Estimate life of components using stress life, strain life and LEFM approach.</td>
</tr>
<tr>
<td>CO4</td>
<td>Categorize different types of surface failures.</td>
</tr>
</tbody>
</table>

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit III, IV, V and Two questions each from units I & II.
Course Content:

UNIT - I
Introduction to Finite Element Method: Basic Steps in Finite Element Method to solve mechanical engineering Solid Mechanics problems: Functional approach and Galerkin approach, Displacement Approach: Admissible Functions, Convergence Criteria: Conforming and Non-Conforming elements, \( C_0, C_1 \) and \( C_n \) Continuity Elements. Basic Equations, Element Characteristic Equations, Assembly Procedure, Boundary and Constraint Conditions. 8 Hours

UNIT - II
Solid Mechanics: One-Dimensional Finite Element Formulations and Analysis – Bars- uniform, varying and stepped cross section- Basic (Linear) and Higher Order Elements Formulations for Axial and Temperature Loads with problems. Beams- Basic (Linear) Element Formulation for uniform and stepped cross section- for different loading and boundary conditions with problems. Trusses: Basic (Linear) Elements Formulations for different boundary and loading condition - Axial and Temperature Loads with problems. 9 Hours

UNIT - III
Two Dimensional Finite Element Formulations for Solid Mechanics Problems: Triangular Membrane/CST Element, Four-Noded Quadrilateral Membrane QUAD 4 Element Formulations for in-plane loading with sample problems. Shape functions for Higher order Triangular and Quadrilateral membrane elements Triangular Axi-symmetric basic Element formulation for aixi-symmetric loading with sample problems. Serendipity and Lagrange family Elements. 8 Hours

UNIT - IV
Three Dimensional Finite Element Formulations for Solid Mechanics Problems: Finite Element Formulation of 4 noded Tetrahedral Element, 8 noded Hexahedral Element, Shape functions for Higher order elements. 6 Hours

UNIT - V
Dynamic Analysis: Finite Element Formulation for point/lumped mass and distributed masses system, Finite Element Formulation of one dimensional dynamic analysis: bar, truss and beam element. Finite Element Formulation of Two dimensional dynamic analysis: triangular membrane element. Evaluation of eigen values and eigen vectors applicable to bars and beams. 08 Hours.

Text Books:
Reference Books:

Self-Study:
On FEM analysis of machine members by using reputed commercial software for stress distribution, stress concentration and report writing on results of analysis.

Course Outcomes:
Upon completion of this course, the students will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Develop governing equation for a mechanical system and apply principles of variation and integral formulation to formulate finite element equations.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Formulate one dimensional, two dimensional and axisymmetric elements.</td>
</tr>
<tr>
<td>CO3</td>
<td>Analyse problems related to 1D, 2D and solids of revolution.</td>
</tr>
<tr>
<td>CO4</td>
<td>Develop mass matrices and compute eigen values and eigen vectors for a 1D and 2D analysis of mechanical components.</td>
</tr>
<tr>
<td>CO5</td>
<td>Demonstrate the use of commercial FEA packages to solve complex problems.</td>
</tr>
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Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.
ELECTIVE - I

<table>
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<th>Course</th>
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Course Content:

UNIT - I
Introduction to Composite Materials: Definition, Classification, Types of matrix material and reinforcements, Characteristics & selection, Fiber composites, Laminated composites, Particulate composites, Prepregs, and sandwich construction.  

UNIT - II

UNIT – III

Failure Criteria: Failure criteria for an elementary composite layer or Ply, Maximum Stress and Strain Criteria, Approximate strength criteria, Inter-laminar Strength, Tsai-Hill theory, Tsai, Wu tensor theory, Numerical problem, practical recommendations.  

UNIT - IV

UNIT - V
Manufacturing, Testing and Applications:

Layup and curing - open and closed mold processing, Hand lay-up techniques, Bag molding and filament winding. Pultrusion, Pulforming, Thermoforming, Injection molding, Cutting, Machining, joining and repair.

NDT tests – Purpose, Types of defects, NDT method - Ultrasonic inspection, Radiography, Acoustic emission and Acoustic ultrasonic method.

Applications: Aircrafts, missiles, Space hardware, automobile, Electrical and Electronics, Marine, Recreational and sports equipment-future potential of composites.  

Text Books:
Reference Books:

Course Outcomes:
Upon completion of this course, the student will be able to

| CO1 | Identify the role of matrices and reinforcements used in practical composite structures. |
| CO2 | Analyze problems on micro and macro mechanical behavior of lamina. |
| CO3 | Assess the strength of laminated composite and predict its failure for given static loading conditions. |
| CO4 | Develop understanding of different methods of manufacturing and testing of composites. |
| CO5 | Make oral presentation on recent advancements in the field of composite materials and structures. |

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.
## MECHATRONICS SYSTEM DESIGN

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits: 03</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>MECHATRONICS SYSTEM DESIGN</td>
<td></td>
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<tr>
<td>Code</td>
<td>16MEMDPEMMD</td>
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</tr>
</tbody>
</table>

### Course Content:

#### UNIT - I


8 Hours

#### UNIT - II

**Electrical Actuation Systems:** Electrical systems, Mechanical switches, Solid state switches, solenoids, DC & AC motors, Stepper motors. System Models: Mathematical models:- mechanical system building blocks, electrical system building blocks, thermal system building blocks, electromechanical systems, hydro-mechanical systems, pneumatic systems.  

9 Hours

#### UNIT - III


10 Hours

#### UNIT - IV

**Data Presentation Systems:** Basic System Models, System Models, Dynamic Responses of System.  

6 Hours

#### UNIT - V

**Advanced Applications in Mechatronics:** Fault Finding, Design, Arrangements and Practical Case Studies, Design for manufacturing, User-friendly design.  

6 Hours

### Text Books:


### Reference Books:

Course Outcomes:
Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Appreciate multi-disciplinary nature of modern engineering systems.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Model and analyse mechanical and electrical systems and their connection.</td>
</tr>
<tr>
<td>CO3</td>
<td>Be able to integrate mechanical, electronics, control and computer engineering in the design of mechatronics systems.</td>
</tr>
<tr>
<td>CO4</td>
<td>Address issues of design, fabrication, and packaging issues of Microsystems.</td>
</tr>
</tbody>
</table>

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.
Course Content:

UNIT - I
Quality by Experimental Design: Quality, western and Taguchi quality philosophy, Elements of cost, Noise factors causes of variation, Quadratic loss function and variation of quadratic loss functions.
Robust Design: Steps in robust design: parameter design and tolerance design, reliability improvement through experiments, illustration through numerical examples.
Experimental Design: Classical experiments: factorial experiments, terminology, factors. Levels, Interactions, Treatment combination, randomization, 2-level experimental design for two factors and three factors. 3-level experiment designs for two factors and three factors, factor effects, factor interactions, Fractional factorial design, Saturated design, Central composite designs, Illustration through numerical examples.

UNIT - II

UNIT - III

UNIT - IV
Parameter Design and Tolerance Design: Parameter and tolerance design concepts, Taguchi’s inner and outer arrays, Parameter design strategy, Tolerance design strategy, Illustrations through numerical examples.

UNIT - V
Reliability Improvement Through Robust Design: Role of S-N ratios in reliability improvement; Case study; illustrating the reliability improvement of routing process of a printed wiring board using robust design concepts.

Text Books:
Reference Books:

Course Outcomes:
Upon completion of this course, the student will be able to

| CO1 | Apply Design of Experiments (DOE) techniques to various methods of design. |
| CO2 | Analyse and evaluate design parameters using different design strategies. |
| CO3 | Illustrate through numerical examples improvements in design parameters. |
| CO4 | Perform case studies involving identification of parameters, analysis of experimental data in a robust design. |

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.
ELECTIVE – II

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits : 03</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>COMPUTATIONAL METHODS IN ENGINEERING ANALYSIS</td>
<td>L T P S</td>
<td>CIE SEE</td>
</tr>
<tr>
<td>Code</td>
<td>16MEMDPECE</td>
<td>3 0 0 0</td>
</tr>
</tbody>
</table>

Course Content:

UNIT - I
Approximations and Round off Errors: Significant figures, accuracy and precision, error definitions, round off errors and truncation errors. Mathematical modeling and Engineering problem solving, simple mathematical model, Conservation Laws of Engineering. 7 Hours

UNIT - II
Roots of Polynomial: Polynomials in Engineering and Science, Muller’s method, Bairstow’s Method Graeffe’s Roots Squaring Method. 9 Hours

UNIT - III
Numerical Differentiation and Numerical Integration: Newton –Cotes and Gauss Quadrature Integration formulae, Integration of Equations, Romberg integration, Numerical Differentiation Applied to Engineering problems, High Accuracy differentiation formulae. 6 Hours

UNIT - IV
Eigen values and Eigen Vectors: Bounds on Eigen Values, Jacobi method for symmetric matrices, Givens method for symmetric matrices, Rutishauser method for arbitrary matrices, Power method, Inverse power method. 9 Hours

UNIT - V
Linear Transformation: Introduction to Linear Transformation, The matrix of Linear Transformation, Linear Models in Science and Engineering
Orthogonality and Least Squares: Inner product, length and orthogonality, orthogonal sets, Orthogonal projections, The Gram-schmidt process, Least Square problems, Inner product spaces. 8 Hours

Text Books:

Reference Books:
Course Outcomes:
Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Construct and analyse mathematical models of physical applications.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Find the roots of polynomials, algebraic, transcendental or simultaneous system of equations in science and engineering problems.</td>
</tr>
<tr>
<td>CO3</td>
<td>Integrate and differentiate a function for given set of tabulated data with greater accuracy for engineering problems.</td>
</tr>
<tr>
<td>CO4</td>
<td>Solve system of linear algebraic equations and compute eigen values and eigen vectors of matrices.</td>
</tr>
<tr>
<td>CO5</td>
<td>Demonstrate use of computational tools like MAT Lab to obtain solution to complex mathematical models.</td>
</tr>
</tbody>
</table>

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, III, V and Two questions each from units II & IV.
<table>
<thead>
<tr>
<th>Name</th>
<th>Credits : 03</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>STATISTICAL MODELING AND EXPERIMENTAL DESIGN</td>
<td>L T P S CIE SEE</td>
<td></td>
</tr>
<tr>
<td>Code</td>
<td>16MEMDPESE</td>
<td>3 0 0 0 50 50</td>
</tr>
</tbody>
</table>

Course Content:

**UNIT - I**
**Statistical Modeling and Data Analysis:** Introduction, Review of basic statistical concepts: Concepts of random variable, Sample and population, Measure of Central tendency; Mean, median and mode. Illustration through Numerical examples, Normal, Log Normal & Weibull distributions. Illustration through Numerical examples.

**UNIT - II**
**Introduction to Designed Experiments:** Strategy of experimentation, Some typical applications of experimental design, Basic principles, Guidelines for designing experiments, A brief history of statistical design, Summary: Using statistical techniques in experimentation.

**UNIT - III**
**Factorial Experiments** Basic definitions, The advantages of factorials, The two factorial design. Introduction, Factorial Experiments Terminology: factors, levels, interactions, Two-level experimental designs for two factors and three factors. Illustration through Numerical examples.

**UNIT - IV**
**Regression Analysis:** linear and multiple Regression analysis, Mathematical models from experimental data. Illustration through Numerical examples.

**UNIT - V**
**Signal to Noise Ratio:** Evaluation of sensitivity to noise. Signal to Noise ratios for static problems: Smaller-the-batter type, Nominal the-better-type, Larger-the better type. Signal to Noise for Dynamic problems. Illustration through Numerical examples.

**Text Books:**

**Reference Book:**
Course Outcomes:
Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Statistically model a population and fit in a suitable distribution for the population for further analysis.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Analyse and apply statistical concept in the design of experiments.</td>
</tr>
<tr>
<td>CO3</td>
<td>Develop experimental models for 2 factors or 3 factors.</td>
</tr>
<tr>
<td>CO4</td>
<td>Establish a regression pattern for given mathematical model established for experiment and evaluate signal to noise ratio for sensitivity.</td>
</tr>
</tbody>
</table>

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.
Course: OPTIMIZATION TECHNIQUES

<table>
<thead>
<tr>
<th>Name</th>
<th>Credits : 03</th>
<th>Marks</th>
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<tbody>
<tr>
<td>Code</td>
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</tbody>
</table>

Course Content:

UNIT - I

UNIT - II

UNIT - III

UNIT - IV
Constrained Optimization Algorithms: Kuhn Tucker conditions, Transformation Methods: Penalty Function Method, Method of Multipliers, Sensitivity analysis. 4 Hours

UNIT - V
Further Topics in Optimization Techniques: Quadratics Programming, sequential quadratic programming; Integer Programming, Penalty Function Method, Branch and Bound Method, Geometric Programming, Applications Design of experiments and Taguchi method – Application and problem solving; Dynamic programming, principle of optimality, recursive equation approach and applications; Genetic algorithm. 10 Hours

Text Books

Reference Books
Course Outcomes:
Upon completion of this course, the student will be able to

| CO1 | Formulate engineering optimization problem and solve LPP by simplex method. |
| CO2 | Solve single and multivariable optimization problem by various relevant method. |
| CO3 | Develop algorithm for constrained optimization. |
| CO4 | Examine various optimization techniques and demonstrate their applicability. |

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, III, IV and Two questions each from units II & V.
Course Content:

Experiment #1
**Numerical Calculation and MATLAB Simulation**
Part A: Invariants, Principal stresses and strains with directions
Part A: Maximum shear stresses and strains and planes, von-Mises stress
Part C: Calculate and Plot Stresses in Thick-Walled Cylinder

Experiment #2
**Stress analysis in curved beam in 2D**
Part A: Experimental studies using Strain Gauge Instrumentation.
Part B: 2D Photo elastic Investigation.
Part C: Modelling and Numerical Analysis using FEM.

Experiment #3
**Stress analysis of rectangular plate with circular hole under i. Uniform Tension and ii. shear**
Part A: Matlab simulation for Calculation and Plot of normalized hoop Stress at hole boundary in Infinite Plate
Part B: Modelling of plate geometry under chosen load conditions and study the effect of plate geometry.
Part C: Numerical Analysis using FEA package.

Experiment #4
**Single edge notched beam in four point bending**
Part A: Modelling of single edge notched beam in four point bending.
Part B: Numerical Studies using FEA.
Part C: Correlation Studies.

Experimental #5
**Torsion of Prismatic bar with rectangular cross-section.**
Part A: Elastic solutions, MATLAB Simulation
Part B: Finite Element Analysis of any chosen geometry.
Part C: Correlation studies.

Experiment #6
**Contact Stress Analysis of Circular Disc under diametrical compression**
Part A: 3-D Modelling of Circular Discs with valid literature background, supported with experimental results on contact stress.
Part B: Numerical Analysis using any FEA package.
Part C: 2D Photo Elastic Investigation.

Experiment #7
**Vibration Characteristics of a Spring Mass Damper System.**
Part A: Analytical Solutions.
Part B: MATLAB Simulation, Part C: Correlation Studies.
Experiment #8
Modelling and Simulation of Control Systems using MATLAB

Part A: Analytical Solutions.
Part B: MATLAB Simulation.
Part C: Correlation Studies.

Course Outcomes:

Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>CO1</td>
<td>Acquire knowledge of stresses, strains and failure theories and analyse them in terms of mathematical models.</td>
</tr>
<tr>
<td>CO2</td>
<td>Design and conduct experiments involving photo elasticity and strain gauges.</td>
</tr>
<tr>
<td>CO3</td>
<td>Apply Experimental techniques for different engineering problems.</td>
</tr>
<tr>
<td>CO4</td>
<td>Use MATLAB and Finite element analysis software and make comparison with other techniques.</td>
</tr>
<tr>
<td>Name</td>
<td>Research Methodology</td>
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<tr>
<td>Code</td>
<td>16APRDICRM</td>
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</table>

### Course Content:

**Module 1:**
Meaning, Objectives and Characteristics of research - Research methods Vs Methodology - Types of research - Descriptive Vs. Analytical, Applied Vs. Fundamental, Quantitative Vs. Qualitative, Conceptual Vs. Empirical - Research process - Criteria of good research - Developing a research plan.

**Module 2:**
Defining the research problem - Selecting the problem - Necessity of defining the problem - Techniques involved in defining the problem - Importance of literature review in defining a problem - Survey of literature - Primary and secondary sources - Reviews, treatise, monographs, patents - web as a source - searching the web - Identifying gap areas from literature review - Development of working hypothesis.

**Module 3:**

**Module 4:**
Aim of this part of the course: is to strengthen students minds towards high quality research through publications, patents and also to learn research ethics. Publications (8-9 hours) Research concepts (2 hour) Research importance on economy, Research in India and abroad, Importance of publications, Why, where, when to publish? Publication ethics (2 hour), Plagiarism (how to use turn it in effectively), International ethics on research, What and what not to publish, Ethical guidelines, Case studies Quality vs quantity (2 hour) Searching literature with high quality, Impact factor, Citations (google scholar vs web of science), H-index, Case studies How to write paper (2 hour), In High quality journals, Conference Articles, Poster preparation, PhD thesis, Inclusion of References Journal reviewing process (1 hour), Selection of the good journal, Knowledge bout journal template, Refereeing process, Research topic selection, Research today and tomorrow, Lab scale to Industry, Traditional research to Technology based research

**Module 5: Self study**
Interpretation and report writing - Techniques of interpretation - Structure and components of scientific reports - Different steps in the preparation - Layout, structure and language of the report - Illustrations and tables - Types of report - Technical reports and thesis.

### REFERENCES:
Course Content:

UNIT - I
12 Hours.

UNIT - II
12 Hours

UNIT - III
12 Hours

UNIT - IV
6 Hours

UNIT - V
Fatigue crack propagation and applications of fracture mechanics: Crack growth and the stress intensity factor. Factors affecting crack propagation. Variable amplitude service loading, Means to provide fail-safety, required information for fracture mechanics approach, Mixed mode (combined) loading and design criteria.
8 Hours

Text Books:

Reference Books:
Course Outcomes:
Upon completion of this course, the student will be able to

| CO1 | Develop a strong foundation in theory, concepts and principles of fracture mechanics |
| CO2 | Use these principles to evaluate fracture mechanics parameters and characterize status of crack in a structure under different loads |
| CO3 | Predict crack propagation, perform failure analysis of engineering structures and provide alternate solutions |
| CO4 | Acquire judgment and skills in solving theoretical and practical problems |
| CO5 | Use a commercial analysis tool to perform fracture mechanics analysis. |

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.
Course Content:

UNIT - I
Review of Mechanical Vibrations: Basic concepts; free vibration of single degree of freedom systems with and without damping, forced vibration of single DOF-systems, Natural frequency. Transient Vibration of single Degree-of freedom systems: Impulse excitation, Arbitrary excitation, Laplace transform formulation, Pulse excitation and rise time, Shock response spectrum. 12 hours

UNIT - II

UNIT - III
Modal analysis, Dynamic Testing of machines and Structures, Experimental Modal analysis, Non Linear Vibrations: Introduction, Sources of nonlinearity, Qualitative analysis of nonlinear systems. Phase plane, Conservative systems, Stability of equilibrium, Method of isoclines, Perturbation method, Method of iteration, Self-excited oscillations. 10 hours

UNIT - IV
Continuous Systems: Vibrating string, longitudinal vibration of rods, Torsional vibration of rods, Euler equation for beams. 05 hours

UNIT - V
Fundamentals of Acoustics: Human perception of sound, Sound wave propagation in 1-D, 3-D space. 3-D wave equation, Some important acoustic quantities and relations. 04 hours

Text Books

Reference Books
Course Outcomes:

Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Model and analyse a free damped, undamped and forced response of a mechanical system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Develop equation and analyse the transient response of a single degree freedom system.</td>
</tr>
<tr>
<td>CO3</td>
<td>Assess the response characteristics of a continuous mechanical system.</td>
</tr>
<tr>
<td>CO4</td>
<td>Analyse and discuss the behaviour of single degree freedom system for linear and non-linear behaviour.</td>
</tr>
<tr>
<td>CO5</td>
<td>Undertake literature review on unfamiliar problems related to vibration, comprehend it and make presentation to the engineering community.</td>
</tr>
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</table>

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.
To set One question each from unit II, IV, V and Two questions each from units I & III.
Course Content:

UNIT - I

UNIT - II
Journal Bearings: Introduction to idealized full journal bearings. Load carrying capacity of idealized full journal bearings, Sommerfeld number and its significance, short and partial bearings, Comparison between lightly loaded and heavily loaded bearings, effects of end leakage on performance, Numerical problems.  

UNIT - III
Hydrostatic Bearings: Hydrostatic thrust bearings, hydrostatic circular pad, annular pad, rectangular pad bearings, types of flow restrictors, expression for discharge, load carrying capacity and condition for minimum power loss, numerical problems, and hydrostatic journal bearings. EHL Contacts: Introduction to Elasto-hydrodynamic lubricated bearings. Introduction to 'EHL' constant. Grubin type solution. 

UNIT - IV

UNIT - V
Magnetic Bearings: Introduction to magnetic bearings, Active magnetic bearings. Different equations used in magnetic bearings and working principal. Advantages and disadvantages of magnetic bearings, Electrical analogy, Magneto-hydrodynamic bearings. 

Text Books

Reference Books

Course Outcomes:
Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Comprehend basics of tribology and related sciences, theoretical background about processes in tribological system, mechanisms and forms of interaction of friction surfaces.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Analyze hydrodynamic, hydrostatic, Elasto-hydrodynamic bearing condition.</td>
</tr>
<tr>
<td>CO3</td>
<td>Select bearings based on various tribological factors to be considered in moving and rotating parts.</td>
</tr>
<tr>
<td>CO4</td>
<td>Understand the application and limitations Magnetic and porous bearings.</td>
</tr>
<tr>
<td>CO5</td>
<td>Undertake literature survey on unfamiliar problems related to Tribology, comprehend it and make presentation to the engineering community.</td>
</tr>
</tbody>
</table>

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.
ELECTIVE – III

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits : 04</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>THEORY OF PLASTICITY</td>
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<td>Code</td>
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Course Content:

UNIT - I
Definition and scope of the subject, Brief review of elasticity, Octahedral normal and shear stresses, Spherical and deviatoric stress, Invariance in terms of the deviatoric stresses, Engineering and natural strains, Mathematical relationships between true stress and true strains, Cubical dilation, finite strains co-efficient Octahedral strain, Strain rate and the strain rate tensor. 12 Hours

UNIT - II
Material Models, Stress-strain relations, Yield criteria for ductile metal, Von Mises, Tresca, Yield surface for an Isotropic Plastic materials, Stress space, Experimental verification of Yield criteria, Yield criteria for an anisotropic material, flow rule normality of Yield locus, Symmetry and convexity, Deformation of isotropic and kinematic hardening, bilinear stress-strain relationship. 12 Hours

UNIT - III
Plastic stress-strain relations, Prandtl-Reuss Saint Venant, Levy-Mises, Experimental verification of the Prandtl-Reuss equation, Upper and lower bound theorems. Application to problems: Uniaxial tension and compression. 08 Hours

UNIT - IV
Bending of beams, Torsion of rods and tubes, Nonlinear bending and torsion equations, Simple forms of indentation problems using upper bounds, Application of Metal forming: Extrusion, Drawing, Rolling and Forging. 10 Hours

UNIT - V
Slip line theory, Introduction, Basic equations for incompressible two dimensional flow, continuity equations, Stresses in conditions of plain strain convention for slip-lines, Geometry of slip lines, Properties of slip lines, 08 Hours

Text Books

Reference Books
Course Outcomes:
Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Analyse and determine the elastic and elastoplastic stress-strain behaviour of solid deformable bodies subjected to various types of loads.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Analyse and assess the yielding behaviour in metallic material using suitable yield criteria.</td>
</tr>
<tr>
<td>CO3</td>
<td>Develop plastic stress-strain relation for large plastic deformation and apply same along with knowledge of yield criteria to various metal forming process.</td>
</tr>
<tr>
<td>CO4</td>
<td>Develop fundamental equations of slipline field theory.</td>
</tr>
</tbody>
</table>

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, III, V and Two questions each from units II & IV.
**Course Content:**

**UNIT - I**

**Fluid Film Lubrication:** Basic theory of fluid film lubrication, Derivation of generalized Reynolds equations, Boundary conditions, Fluid film stiffness and Damping coefficients, Stability and dynamic response for hydrodynamic journal bearing, Two lobe journal bearings.

**Stability of Flexible Shafts:** Introduction, equation of motion of a flexible shaft with rigid support, Radial elastic friction forces, Rotary friction, friction Independent of velocity, friction dependent on frequency, Different shaft stiffness Constant, gyroscopic effects, Nonlinear problems of large deformation applied forces, instability of rotors in magnetic field. **12 Hours**

**UNIT - II**

**Critical Speed:** Dunkerley's method, Rayleigh's method, Stodola's method. Rotor Bearing System: Instability of rotors due to the effect of hydrodynamic oil layer in the bearings, support flexibility, Simple model with one concentrated mass at the center. **6 Hours**

**UNIT - III**

**Turborotor System Stability by Transfer Matrix Formulation:** General turborotor system, development of element transfer matrices, the matrix differential equation, effect of shear and rotary inertia, the elastic rotors supported in bearings, numerical solutions. **10 Hours**

**UNIT - IV**

**Turborotor System Stability by Finite Element Formulation:** General turborotor system, generalized forces and co-ordinates system assembly element matrices, Consistent mass matrix formulation, Lumped mass model, linearised model for journal bearings, System dynamic equations Fix stability analysis non dimensional stability analysis, unbalance response and Transient analysis. **14 Hours**

**UNIT - V**

**Blade Vibration:** Centrifugal effect, Transfer matrix and Finite element, approaches. **8 Hours**

**Text Books:**

**Reference Books:**
## Course Outcomes:

Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Model a rotating machine element theoretically for rotor dynamic analysis.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Analyse Free and Forced lateral response of simple rotor models and of more complex systems including shafts, bearings, seals and stators.</td>
</tr>
<tr>
<td>CO3</td>
<td>Formulate Finite element and carry out analysis for Turborotor System Stability.</td>
</tr>
<tr>
<td>CO4</td>
<td>Apply Finite element approach to blade vibration.</td>
</tr>
</tbody>
</table>

### Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.

To set One question each from unit II, III, V and Two questions each from units I & IV.
Course Content:

UNIT - I
Bending of long rectangular plate into a cylindrical surface: Differential equation - Bending of plates with different boundary conditions - Long plate on elastic foundation.
Pure Bending: Moment and curvature relations problems of simply supported plates-Strain energy impure bending. 10 Hours

UNIT - II
Symmetrical Bending of Circular Plates: Differential equation uniformly loaded plates, Plates concentricity loaded plates- loaded at the center. 08 Hours

UNIT - III
Rectangular Plates: Differential equations - Solution of simply supported plate Various loading conditions, viz, uniformly distributed load, hydrostatic pressure and concentrated load, central as well as non-central, Navier and Levy type solutions with various edge boundary conditions, viz., all edges simply supported, Two opposite edge fixed and two adjacent fixed. Bending of plate under combined action of lateral and transverse loads derivation of differential equation, simply supported rectangular plate. 10 Hours

UNIT - IV
Introduction to Shell Structures - General description of various types. Membrane Theory of thin shells (Stress Analysis): Cylindrical shells - Spherical Shells- Shells of double curvature, Viz, cooling tower Hyperbolic, Parabolic and elliptic paraboloid. 08 Hours

UNIT - V
Membrane Deformation of Shells: Symmetrical 'loaded shell, symmetrically loaded spherical shell. General Theory of cylindrical shells: Circular; Cylindrical shell loaded symmetrically.
General equation of circular cylindrical shells. Approximate investigation of: bending of circular cylindrical shell. 08 Hours

Text Books:

Reference Books
Course Outcomes:
Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Understand and develop basic equations for thin plates.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Develop pure bending equations for circular and rectangular plates.</td>
</tr>
<tr>
<td>CO3</td>
<td>Analyze the rectangular plates using Navier and Levy approach.</td>
</tr>
<tr>
<td>CO4</td>
<td>Develop equations for combined loading on plates.</td>
</tr>
</tbody>
</table>

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, II, IV and Two questions each from units III & V.
## ELECTIVE – IV

<table>
<thead>
<tr>
<th>Name</th>
<th>EXPERIMENTAL MECHANICS</th>
<th>Credits : 03</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>16MEMDPEEM</td>
<td>L T P S CIE SEE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 0 0 0 50 50</td>
<td></td>
</tr>
</tbody>
</table>

| Course Content: |

### UNIT - I
**Introduction:** Definition of terms, calibration, standards, dimensions and units, generalized measurement system, Basic concepts in dynamic measurements, system response, distortion, impedance matching, experiment planning. General data acquisition system, Basic components, data transmission

**Analysis of Experimental Data:** Statistical analysis of experimental data- Probability distribution, Gaussian, normal distribution. Chi-square test, Method of least square, correlation coefficient, multivariable regression, standard deviation of mean, graphical analysis and curve fitting  

8 Hours

### UNIT - II
**Force, Torque and Strain Measurement:** Mass balance measurement, Elastic Element for force measurement, torque measurement. Strain Gages -Strain sensitivity of gage metals, Gage construction, Gage sensitivity and gage factor, Performance characteristics, Environmental effects Strain, gage circuits, Potentiometer, Wheat Stone's bridges, Strain Analysis Methods-Two element and three element, rectangular and delta rosettes, Correction for transverse strains effects  

8 Hours

### UNIT - III
**Stress Analysis:** Two Dimensional Photo elasticity - Nature of light, wave theory of light, optical interference - Polariscope stress optic law - effect of stressed model in plane and circular Polariscope, Isoclinics, Iso-chromatics fringe order determination - Fringe multiplication techniques - Calibration Photoelastic model materials.

Three Dimensional Photo elasticity: Shear difference method, Oblique incidence method, Secondary principals stresses, Scattered light photo elasticity.  

9 Hours

### UNIT - IV
**Coating Methods: a) Photoelastic Coating Method-Birefringence coating techniques Sensitivity Reinforcing and thickness effects - data reduction - Stress separation techniques b) Brittle Coatings Method: Brittle coating technique Principles data analysis - coating materials, Coating techniques. c) Moire Technique - Geometrical approach, Displacement approach**  

7 Hours

### UNIT - V
**Holography:** Introduction, Equation for plane waves and spherical waves, Intensity, Coherence, Spherical radiator as an object (record process), Hurter, Driffeld curves, Reconstruction process, Holographic interferometry, Realtime. and double exposure methods, Displacement measurement, Isopachies.  

7 Hours

### Text Books:

Reference Books:

Course Outcomes:
Upon completion of this course, the student will be able to

| CO1 | Understand functional requirements of a generalized measurement system and identify suitable components for an application. |
| CO2 | Use concepts of Data Acquisition, Processing and apply the same for interpretation and analysis of experimental data. |
| CO3 | Determine stresses and strains in a structure using different methods such as strain gages, photo-elasticity, brittle coating and holography. |
| CO4 | Identify and apply suitable experimental stress analysis to practical problems. |

Scheme of Examination for Semester End Examination:
Answer Five Full questions selecting one from each unit.
To set One question each from unit I, IV, V and Two questions each from units II & III.
Course Content:

UNIT - I

Tolerance Analysis: Process capability, mean, variance, skewness, kurtosis, Process capability metrics, \( C_p, C_{pk} \), Cost aspects, Feature tolerances, Geometries tolerances, Geometric tolerances, Surface finish, Review of relationship between attainable tolerance grades and different machining process. Cumulative effect of tolerance- Sure fit law and truncated normal law. 10 Hours

UNIT - II
Selective Assembly: Interchangeable part manufacture and selective assembly. Deciding the number of groups -Model-1: Group tolerance of mating parts equal, Model total and group tolerances of shaft equal. Control of axial play-Introducing secondary machining operations, Laminated shims, examples. Datum Features: Functional datum, Datum for manufacturing, Changing the datum. Examples. 8 Hours

UNIT - III
Design Considerations: Design of components with casting consideration. Pattern, Mould, and Parting line. Cored holes and Machined holes. Identifying the possible and probable parting line. Casting requiring special sand cores. Designing to obviate sand cores. Component Design: Component design with machining considerations link design for turning components-milling, Drilling and other related processes including finish- machining operations. 10 Hours

UNIT - IV
True positional theory: Comparison between co-ordinate and convention method of feature location. Tolerance and true position tolerancing virtual size concept, Floating and fixed fasteners. Projected tolerance zone. Assembly with gasket, zero position tolerance. Functional gauges, Paper layout gauging. 6 Hours

UNIT - V
Design of Gauges: Design of gauges for checking components in assemble with emphasis on various types of limit gauges for both hole and shaft. 5 Hours

Text Books:
Course Outcomes:

Upon completion of this course, the student will be able to

| CO1 | Understand the role of manufacture and assembly in development of mechanical parts and their assemblies. |
| CO2 | Apply manufacturing considerations in the design and development of components made of casting and machining. |
| CO3 | Apply geometrical dimensioning and tolerances issues in mechanical design. |

Scheme of Examination for Semester End Examination:

Answer Five Full questions selecting one from each unit.
To set One question each from unit II, IV, V and Two questions each from units I & III.
Course Content:

UNIT - I

11 Hours

UNIT - II
Velocity and Statics of Manipulators: Differential relationships, Jacobian, Differential motions of a frame (translation and rotation), Linear and angular velocity of a rigid body, Linear and angular velocities of links in serial manipulators, 2R, 3R manipulators, Jacobian of serial manipulator, Three DOF parallel manipulator. Velocity ellipse of 2R manipulator, Singularities of serial and parallel manipulators 2R, 3R, four bar mechanism, three DOF parallel manipulator, Statics of serial manipulators, Static force and torque analysis of 3R manipulator, Statics of parallel manipulator, Singularity in force domain.

Dynamics of Manipulators: Inertia of a link, Recursive formulation of dynamics using Newton Euler equation, Equation of motion of 2R and 3R manipulators using Lagrangian, Newton-Euler formulation.  
12 Hours

UNIT - III
Trajectory Planning: Joint space schemes, cubic trajectory, Joint space schemes with via points, Cubic trajectory with a via point, Third order polynomial trajectory planning, Linear segments with parabolic blends, Cartesian space schemes, Cartesian straight line and circular motion planning, Trajectory planning for orientation.  
5 Hours

UNIT - IV
Control: Feedback control of a single link manipulator- first order, second order system, PID control, PID control of multi-link manipulator, Non-linear control of manipulators-computed torque method, Force control of manipulator, Cartesian control of manipulators, Force control of manipulators-force control of single mass, Partitioning a task for force and position control- lever, peg in hole Hybrid force and position controller.  
5 Hours
UNIT - V

**Actuators:** Types, Characteristics of actuating system: weight, Power to- weight ratio, Operating pressure, Stiffness vs. compliance, Use of reduction gears, Comparison of hydraulic, Electric, pneumatic actuators, Hydraulic actuators, Proportional feedback control, Electric Motors: DC motors, Reversible AC motors, Brushless DC motors, Stepper motors- structure and principle of operation, Stepper motor speed-torque characteristics.

**Sensors:** Sensor characteristics, Position sensors- potentiometers, Encoders, LVDT, Resolvers, Displacement sensor, Velocity sensor- encoders, tachometers, Acceleration sensors, Force and Pressure sensors - piezoelectric, force sensing resistor, Torque sensors, Touch and tactile sensor, Proximity sensors-magnetic, Optical, Ultrasonic, Inductive, Capacitive, Eddy-current proximity sensors.

**Text Books:**

**Reference Books:**

**Course Outcomes:**
Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Formulate a representation for links using Denavit-Hartenberg parameters.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Derive and analyze the velocity and statics of a manipulator.</td>
</tr>
<tr>
<td>CO3</td>
<td>Plan and develop trajectory with different schemes.</td>
</tr>
<tr>
<td>CO4</td>
<td>Characterize and choose different actuators and sensors for robotic applications.</td>
</tr>
</tbody>
</table>

**Scheme of Examination for Semester End Examination:**
Answer Five Full questions selecting one from each unit.
To set One question each from unit III, IV, V and Two questions each from units I & II.
Course Content:

Experiment #1
**Structural Analysis**
Part B: Buckling, Bending and Modal analysis of stiffened Panels.
Part C: Parametric Studies.

Experiment #2
**Design Optimization**
Part A: Shape Optimization of a rotating annular disk.
Part B: Weight Minimization of a Rail Car Suspension Spring.
Part C: Topology Optimization of a Bracket.

Experiment #3
**Thermal analysis**
Part A: Square Plate with Temperature Prescribed on one edge and Opposite edge insulated.
Part B: A Thick Square Plate with the Top Surface exposed to a Fluid at high temperature, Bottom Surface at room temperature, Lateral Surfaces Insulated.

Experiment #4
**Thermal Stress Analysis**
Part A: A Thick Walled Cylinder with specified Temperature at inner and outer Surfaces.
Part B: A Thick Walled Cylinder filled with a Fluid at high temperature and Outer Surface exposed to atmosphere.

Experiment #5
**CFD Analysis**
Part A: CFD Analysis of a Hydro Dynamic Bearing using commercial code.
Part B: Comparison of predicted Pressure and Velocity distributions with Target solutions.
Part C: Experimental Investigations using a Journal Bearing Test Rig.
Part D: Correlation Studies.

Experiment #6
**Analysis of Welded Joints.**
Part B: FE Modeling and Failure Analysis.
Part C: Correlation Studies.
Experiment #7
Analysis of Bolted Joints.
Part B: FE Modeling and Failure Analysis.
Part C: Correlation Studies.

Experiment #8
Adhesive Bonded Joints.
Part B: FE Modeling and Failure Analysis.
Part C: Correlation Studies.

Course Outcomes:
Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Get basic knowledge of Buckling, bending, CFD, Bolted and Welded joints.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Fabricate and test Bolted, Welded and Adhesive bonded joints.</td>
</tr>
<tr>
<td>CO3</td>
<td>Perform FE modelling and optimization of simple panels, joints and rotating discs.</td>
</tr>
<tr>
<td>CO4</td>
<td>Demonstrate Failure, Thermal and CFD analysis of FE models using different software packages</td>
</tr>
</tbody>
</table>
### Course: 16MEMDPCIN - INTERNSHIP / INDUSTRIAL TRAINING

<table>
<thead>
<tr>
<th>Name</th>
<th>Credits : 21</th>
<th>Marks</th>
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<tr>
<td>INTERNSHIP / INDUSTRIAL TRAINING</td>
<td>L T P S</td>
<td>CIE SEE</td>
</tr>
<tr>
<td>Code</td>
<td>16MEMDPCIN</td>
<td>0 0 21 0</td>
</tr>
</tbody>
</table>

**Course Objectives:**
To satisfy the requirements for the internship, students will:
- explain the operation of the industrial facility in which they worked
- describe the professional skills they developed during their internship
- demonstrate communication skills (written and oral)

**Course Outcomes:**
Upon completion of this course, the student will be able to

| CO1 | Design/ appraise the working of a system/organization, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. |
| CO2 | Function in multi-disciplinary teams |
| CO3 | Identify, formulate, and solve engineering problems |
| CO4 | Understand professional and ethical responsibility |
| CO5 | Gain knowledge of contemporary issues |
| CO6 | Use the techniques, skills, and modern engineering tools necessary for engineering practice |

### Course: 16MEMDPCS2 - TECHNICAL SEMINAR

<table>
<thead>
<tr>
<th>Name</th>
<th>Credits : 02</th>
<th>Marks</th>
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</thead>
<tbody>
<tr>
<td>TECHNICAL SEMINAR</td>
<td>L T P S</td>
<td>CIE SEE</td>
</tr>
<tr>
<td>Code</td>
<td>16MEMDPCS2</td>
<td>0 0 2 0</td>
</tr>
</tbody>
</table>

**Course Objectives:**
Upon completion of this course, the student will be able to

| CO1 | Identify and understand current trends and real-world issues related to topics in Machine Design. |
| CO2 | Classify appropriate content and sources, through literature survey, that can be summarised and integrated into presentation |
| CO3 | Review, analyse, and interpret data & results using critical thinking skills |
| CO4 | Revise and present scientific case studies in presentation |
| CO5 | Collaborate effectively with other students in analysing results and preparing oral presentations |
| CO6 | Prepare a technical seminar report and communicate effectively through oral presentation using multimedia tools |
### Course

<table>
<thead>
<tr>
<th>Name</th>
<th>PROJECT WORK</th>
<th>Credits : 27</th>
<th>Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>16MEMDPCP1 &amp; 16MEMDPCPR</td>
<td>L 0</td>
<td>T 0</td>
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</tbody>
</table>

#### Course Outcomes:

Upon completion of this course, the student will be able to

<table>
<thead>
<tr>
<th>CO1</th>
<th>Apply relevant knowledge and skills acquired during the course in the domain to the problem on hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2</td>
<td>Formulate the specifications of the project work, identify a set of feasible solutions and prepare and execute project plan considering professional, cultural and societal factors</td>
</tr>
<tr>
<td>CO3</td>
<td>Extract information pertinent to problem using literature survey</td>
</tr>
<tr>
<td>CO4</td>
<td>Analyze independently and discuss complex issues</td>
</tr>
<tr>
<td>CO5</td>
<td>Use appropriate techniques and tools to conduct experiments, analyze data</td>
</tr>
<tr>
<td>CO6</td>
<td>Evaluate and critically examine the outcomes of one’s own work and others’ work</td>
</tr>
<tr>
<td>CO7</td>
<td>Draw suitable conclusions based on the results and identify relevant applications</td>
</tr>
<tr>
<td>CO8</td>
<td>Document the findings and prepare a report in the prescribed format</td>
</tr>
<tr>
<td>CO9</td>
<td>Demonstrate working knowledge of ethics and professional responsibility at different stages such as formulation, design, implementation, and presentation</td>
</tr>
<tr>
<td>CO10</td>
<td>Publish the outcomes of the project work in a reputed journal, make effective presentation of the work and communicate confidently in defending the work</td>
</tr>
</tbody>
</table>
ASSESSMENT:

Continuous Internal Evaluation (CIE) includes mid-term tests, weekly/fortnightly class tests, homework assignments, problem solving, group discussions, quiz, seminar, mini-project and other Alternate Assessment Tools (AAT) prescribed by the faculty handling a course prior to beginning of the classes.

Semester End Examination (SEE) - A written examination for theory courses and practical/design examination with built-in oral part (Viva-Voce).

Both CIE and SEE have equal (50:50) weightage. The Student's performance in a course shall be judged individually and together based on the results of CIE and SEE.

Breakup of CIE Components for Courses in General:

<table>
<thead>
<tr>
<th>Component</th>
<th>Test-1</th>
<th>Test-2</th>
<th>AAT</th>
<th>Total Marks</th>
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<tbody>
<tr>
<td>Maximum Marks</td>
<td>15</td>
<td>15</td>
<td>20</td>
<td>50</td>
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</table>

Breakup of CIE Components for Integrated Courses:

<table>
<thead>
<tr>
<th>Component</th>
<th>Theory</th>
<th>Practical</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test-1</td>
<td>Test-2</td>
<td>AAT</td>
</tr>
<tr>
<td>Maximum Marks</td>
<td>10</td>
<td>10</td>
<td>05</td>
</tr>
</tbody>
</table>

Breakup of CIE Components for Comprehensive Courses:

<table>
<thead>
<tr>
<th>Component</th>
<th>Theory</th>
<th>Practical</th>
<th>Self-Study</th>
<th>Total Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test-1</td>
<td>Test-2</td>
<td>AAT</td>
<td>Lab Performance / Record Lab Test</td>
</tr>
<tr>
<td>Maximum Marks</td>
<td>10</td>
<td>10</td>
<td>05</td>
<td>15</td>
</tr>
</tbody>
</table>

Note:
Alternate Assessment Tools, if any, will be announced by concerned Faculty at the beginning of the semester.
In case of Alternative Assessment Tools (such as term papers, assignments, problem solving, micro-projects, seminars, MOOCs etc.) being used by a faculty for a particular course, a maximum of 40% of the total CIE marks can be utilized.